Int. J. Chem. Sci.: 14(4), 2016, 2331-2338
ISSN 0972-768X
www.sadgurupublications.com

DESIGN AND FABRICATION OF LOW COST COMPACT BIO-DIESEL PRODUCTION PLANT

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ABSTRACT

The depletion of fossil fuels and the worst impact on environmental pollution caused of their burning have led to the search for renewable clean energies. Nowadays, there are many sources of renewable energy. Biodiesel is just one source, but a very important one. Biodiesel has been known as an attractive alternative fuel although biodiesel produced from edible oil is very expensive than conventional diesel. Therefore, the uses of biodiesel produced from non-edible oils are much better option. Biodiesel is gaining more and more importance as an attractive fuel due to the depleting fossil fuel resources. Chemically biodiesel is monoalkyl esters of long chain fatty acids derived from renewable feed stock like vegetable oils and animal fats. This paper will describe the engineering design for the reactor vessel development beginning at the stoichiometric equations for the production process and the thermal energy balance to the detail engineering including the equipment selection and fabrication in order to meet the design and objective specifications. Biodiesel produced from cashew shell pyro oil, coconut shell pyro oil, Kikar seeds pyro oil and velikkathan seeds pyro oil are used in this setup to produce the Bio diesel. The bio diesel pyro oil properties are very near to diesel fuel and this design system showed close value to the requirements of diesel standard.

Key words: Cashew nut pyro oil, Bio diesel plant, Reactor vessel, Monoalkyl esters, Trans esterification.

INTRODUCTION

Human development towards advanced society will not be possible without energy recently, there have been major advances in the techniques and technologies used to obtain energy, which allowed to improve well-being for most of the world population. However, parallel to this increase in well-being and comfort is a growing demand on the resources required to get the energy. Morover, because energy is affordable, people tend to consume mre than they really need. The overall energy consumption will keep increasing along with

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the increase in world population. This increase in consumption will become a serious issue as more and more people will have purchasing power, the consuming more and more goods. Such phenomenon will mostly be felt in highly populated cuntries like China and India. For instance, it is believed that the number of car in India will increase from 14 to 48 per 1000, while the number of 2 wheelers from 102 to 393 per 1000 in the next 20 years. The major concern is that the worldwide oil prduction is expected to peak around 2020. At this time, energy connsumption will still be rising exponentially. Therefore, there will be a growing gap between the energy needs and the energy available, which is most likely to result in the cost of energy becoming outrageously expensive.

The most common way to produce biodiesel is by transesterification, which refers to a catalyzed chemical reaction involving vegetable oil and an alcohol to yield fatty acid alky esters (i.e., biodiesel) and glycerol. After the complete conversion of the vegetable oil, the reaction was stopped and the mixture was allowed to stand for phase separation: the ester mixture formed the upper layer and glycerine formed the lower layer. The outstanding benefits of pure plant oils are due to their physico-chemical properties, and by their way of production, which involves few process steps and can be carried out done economically with small production units.

EXPERIMENTAL

Methods of bio-diesel production

Direct use and blending

Two severe problems associated with the use of vegetable oils as fuels were oil deterioration and incomplete combustion. Polyunsaturated fatty acids were very susceptible to polymerization and gum formation caused by oxidation during storage or by complex oxidative and thermal polymerization at the higher temperature and pressure of combustion. The gum did not combust completely, resulting in carbon deposits and lubricating oil thickening Winter rapeseed oil as a diesel fuel was studied because of the high yield and oil content (45%) of winter rapeseed and the high (46.7%) erucic acid content of the oil. The rate of gum formation of winter rapeseed oil was 3 times slower than that of high linoleic (75 ± 85%) oil. The viscosities of 50/50 and 70/30 blends of winter rapeseed oil and diesel and whole winter rape oil were much higher (6 ± 18 times) than No. 2 diesel. A blend of 70/30 winter rapeseed oil and No. 1 diesel was used successfully to power a small single-cylinder diesel engine for 850 h. No adverse wear and no effects on lubricating oil or power output were noted.

Micro emulsions

To solve the problem of the high viscosity of vegetable oils, micro emulsions with solvents such as methanol, ethanol and 1-butanol have been studied. A micro emulsion is defined as a colloidal equilibrium dispersion of optically isotropic microstructures with dimensions generally in the 1 ± 150 nm range formed spontaneously from two normally immiscible liquids and one or more ionic or non-ionic amphiphiles. They can improve spray characteristics by explosive vaporization of the low boiling constituents in the micelles. Short term performances of both ionic and non-ionic micro emulsions of aqueous ethanol in soybean oil were nearly as good as that of No. 2 diesel, in spite of the lower cetane number and energy content. The durabilities were not determined.

Thermal cracking (pyrolysis)

Pyrolysis is a process of extracting oil from solid waste like cashew nut shell, coconut shell. Pyrolysis is the thermal degradation of carbonaceous materials at temperatures between 300^{o}C and 700^{o}C in the absence of oxygen. The process is endothermic and requires an external indirect input of energy typically through the walls of the reactor. The heat volatilizes and decomposes the organic matter to produce a pyrolysis gas, liquid and solid char in relative proportions depending on the process parameters of temperature and pressure.

Bio diesel production systems

The transesterification process can be carried through batch or continues systems. Continuous systems include techniques such as supercritical alcohol, the use of reactive distillation columns, and the use of static mixers. Newer techniques incorporate the use of microwaves and ultrasounds. Batch production is known to be slow, tedious, labor intensive and low in productivity. On the other side, production using continuos flow generally produces more fuel per unit of labor and allows for larger scale projects, thus reducing the overall cost of production.

Supercritical

One of the commonly studies processes is the supercritical method. It is advantagious due to its short reaction time. On the other hand, the alcohol to oil ratio and the reaction temperature are the highest of all process as showed in table. Because of those two reasons, this method was not considered appropriate to suit the needs of energy situation.

Reactive distillations

Another relatively new and unexplored way of producing is the reactive distillation method. It implies simultaneous chemical reactions and distillation processes in a counter current column. The reaction time is not much longer than for the supercritical method, while the alcohol to oil ratio as well as the reactor temperature are both considerably lower.

Design considerations

Sizing parameters

Another important criterion to consider while sizing the equipment is the alcohol to oil molar ratio. The general accepted value is six moles of methanol for one mole of oil. However, with this apparatus, the students are aiming to decrease the molar ratio. The last design factor to be fixed is the unit process time. The maximum running time has been fixed to 1hour: during the first 30min, adjustments will be made and the unit is expected to reach its maximum conversion capacity during that time period; during the last 30min, the unit should work under its full potential and samples could be taken. In addition, having a production time set to 1 hour allows separation process to be done.

Gravity

One of the major feature and advantage of the system is that it uses gravity. This offers many advantages. First, using valves is enough to regulate the methanol and oil flows since they are relatively small. Consequently, it decreases material requirement since no pump or flow meter is required. Secondly, it decreases the energy consumption of the system and makes it more energy efficient. However there are also disadvantages associated with valve regulated flows: a longer time is required to set-up an experimental run and flows might be less accurate and fluctuating.

Versatile

Another important point that has been considered is the versatility of the system. Since this is a research unit, many types of experiments must be easily performed and the unit should be easily modified in order to suit the experimental set-ups. One of the major features is that every component can be by-passed. Connections and pipes have been installed for easy redirection of the flow. This enables the study of each component and a good understanding of its influence on the overall conversion of oil to biodiesel. In addition, the structural frame is done with slotted angles; therefore, components can easily be moved or added.

Monitoring

In order to understand the system, monitoring of the temperature is essential. Also, the temperatures of reactor are to be constant at all time to 55 to 60 degree Celsius. If any sound is occurred during the working we must off the reactor.

Design of biodiesel plant

Design specifications

The stoichiometric equation mentioned the design specifications are set as follows:

(a) Above 90 % of conversion shall be achieved

(b) Compatible materials must be used

(c) Atmospheric operation pressure

(d) Vessel capacity: 2 gallons

(e) Hot water is used for heat supply

(f) Ideal mixing in the continuous stirrer reactor vessel

The conversion factor above 90% is determined in a weight percentage of how much fatty acid methyl ester (biodiesel) is earned per gallon of palm oil.

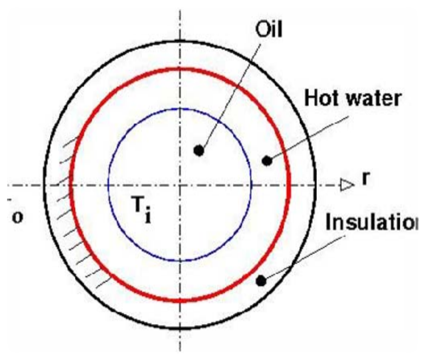

Fig. 1: Diagrammatic view of biodiesel plant reactor vessel

The material for the inner vessel and the stirrer is made of stainless steel that is compatible to the chemical properties of the oil and glycerine. Zink is used for the outer vessel and a rock wool is utilized as the insulation material preventing a heat loss out the inner vessel. The heat transfer of the composite walls made of SS 304 at the inner and Zink at the outer vessel along with the insulation material for reducing heat loss to the surroundings has been ascertained to select the electrical heater. 1.5 kW and 2.5 kW are chosen for the esterification and transesterification process heaters, respectively. These different heats sources are selected since the residential time of both processes are various. The first process takes approximately 30 min and the second ones require two to three hours longer for the reaction completeness. As the heat supply to the process is the hot water that heated by the electrical heater and this mechanism can avoid the temperature fluctuation especially in the radial direction. It keeps the temperature uniformity during the reaction. A thermostat is used to set the operating temperature of 65°C keeping the methanol at liquid phase.

Working of biodiesel plant

The vegetable oil is poured in the reactor vessel, then the motor is ON, then the reactant (methanol) is added in to the tank. The oil and stirrer mixes the oil and the reactant and simultaneously catalyst is added in to the reactor vessel. In order to reduces the time consumption correct quantity of catalyst is added.

Fig. 2: Photographic view of biodiesel plant

The catalyst we have taken NaOH, is more alkalyic and easy for handling and it is cheaply available. Hot water is supplied at 65°C. Hot water is used to speed up the reaction. After 30 min the motor is kept OFF and it is set ideal for the sedimentation of glycerine. Glycerine is a byproduct which is formed during the reaction. After 30 min the biodiesel is extracted out from the vessel.

RESULTS AND DISCUSSION

Quantity of oil obtained

From the bio diesel plant Table 1 show that production of bio diesel from Cashew shell pyro oil, Coconut shell pyro oil, Kikar seeds pyro oil and velikkathan seeds pyro oil. Cashew shell pyro oil more amount of oil extracted from other three pyro oils, because of Cashew shell pyro oil is more viscosity and density when compare to that of other three fuels.

Table 1: The quantity of biodiesel and by product

Oil	Quantity (mL)	Biodiesel (mL)	Glycerine (mL)	Wastage oil (mL)
Cashew shell oil	1000	750	300	30
Coconut shell oil	1000	650	200	50
Kikarseed oil	1000	550	150	70
Velikkathan seed oil	1000	450	100	80

Properties of biodiesel

Table 2 shows that cashew shell bio diesel properties are very near to diesel fuel compare to that of Coconut shell pyro oil, Kikar seeds pyro oil and velikkathan seeds pyro oil.

Table 2: Properties of biodiesel

Oil	Viscosity (mL)	Density (mL)	Flash point (mL)	Fire point (mL)
Diesel	3.4	860	51	55
Cashew shell oil	4.4	880	58	62
Coconut shell oil	5.5	950	65	70
Kikarseed oil	7.5	990	92	97
Velikkathan seed oil	8.5	1050	87	93

CONCLUSION

Thus bio diesel was prepared from used vegetable oil, the properties resembled closely to that of commercial diesel. Hence it can be used as an alternate for diesel. It is relatively economic than diesel and emits less pollutants. It can be used for Vehicular use, Railway usage, as heating oil when blended with other fuel oil in proportion. The experimental work carried out in this project shows that bio-diesel of acceptable quality can be produced on a small scale from a number of low-cost raw materials. However, the search for alternative feed-stocks needs to be continued. More research on the esterification of used vegetable oil is needed, to establish process requirements for high yield and quality, and to find ways of improving its low-temperature properties so that a higher proportion could be included in bio-diesel blends. The ester yields obtained from all the oils used in these trials have been low in comparison with those obtained from refined vegetable oils in existing large-scale plants. Rising of yields has a significant effect on the economics of bio-diesel production. Modern technology is giving very high yields; it needs to be demonstrated that the same can be achieved with other raw materials, whereas more information is required on alternative uses for small amounts of glycerol.

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Revised : 18.08.2016 *Accepted : 21.08.2016*